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REPORT ON TRAVEL IN EUROPE, SUMMER 1953

Cathleen Morawetz

The purpose of the trip was to gather information on work being done in partial differential equations and applied mathematics at various institutes and universities in Europe. The trip began with a side trip to Toronto where I visited the computing centre at the University.

Toronto

The official head of the Computing Centre is Prof. Watson, the head of the Physics Department, but C. C. Gottlieb runs the mathematical section and discussed the machine with me.

The Perut machine in Toronto is an exact replica of the one in Manchester. Its structural details and computing capacities are all well described in the O.N.R. letter from London about the Manchester machine. This report will be limited to discussing how the machine is being used and some of the problems to date.

The machine has been in use since the first of November. Of 105 hours per week available 20 hours are devoted to scheduled maintenance and between 10 and 20 hours are lost through machine failure -- mostly tube failure or wrong programming. This leaves 65-75 hours per week when the machine is actually functioning.

Because of the frequency with which programming problems come up during operation Dr. Gottlieb believes that every programmer and coder must know how to operate

the machine and the operator must be able to reprogram any section of any problem. This is especially important during night operation since only one programmer is present. The total permanent staff is only between 8 and 10 persons.

The input and output of information (on punched tape) is comparatively slow compared to the operation of the machine itself. This has not proved a limitation to date, partly it is true, because problems have been selected with this limitation in mind.

Most of the operating time in the past six months has been spent on finding the water level behind a dam in the projected St. Lawrence seaway, given a specified water level at the dam and the flow across any cross section (steady state). The water level is computed as a function of distance upstream by conservation of energy using iteration. The energy loss is a non-linear empirical function of the water level determined from the bend of the river, skin friction and turbulence. The principle problem is to keep the water level single-valued when passing around an island or several islands together. The method works well unless the flow between two islands is small and gets reversed during the iteration. Then the solution does not converge and the problem is modified by joining the islands together. The problem has been varied by considering different water levels at the dam, different roughness coefficients, and also modified for ice conditions. The chief difficulty has been in coping with the tremendous volume of data.

Amsterdam, Mathematische Centrum

Apart from the strictly practical problems of the applied mathematicians (just two) there is no work done here in partial differential equations. I therefore did not visit the pure mathematics section. As to the applied mathematics section Van der Corput is looking around for a head for the applied mathematics since he obviously thinks it needs some added stimulation. Berghuis who is actually in the computing section seems to be a very enthusiastic applied mathematician.

The machine here was shown to me by Blaauw (who worked with Aiken) who seems to be a man of well mixed training -- both mathematical and engineering. So far everything is in a very preliminary state. Their old machine is being taken apart and it actually never functioned properly.

The present efforts of the applied mathematics section, consisting of Braakman and Feldkampf, are directed toward flood problems. Along with the computing section (van Wijngaarden and Berghuis) they are undertaking a long computation of the effects of the tides in the deltas of the rivers. At the initial time there is given a continuous velocity and water depth distribution in a river with islands (including a constant velocity upstream in the river). The problem is to determine the velocity and water depth at all later times. Shallow water theory is used in each branch of the stream with friction loss according to Chezy. Conditions at the junctions of

branches of the stream are determined from continuity. At the ocean end of the river the initial velocity and water depth are smooth and depend on the tide. Still shallow banks on the river are accounted for to some extent. This problem is now being set up in characteristic coordinates and will be computed by hand if the machine is not ready for it.

Another problem on which there are only partial results is that of finding theoretically the location of the fresh water reservoirs that lie under the sand dunes along the coast. This involves finding a solution of the Laplace equation in a given region h that satisfies two discontinuity conditions on an inknown curve inside the region and has prescribed normal derivative on one boundary of the region.

One problem that has been solved is finding the distribution of salt in soil under fresh water from measurements of electric currents in the water. Like practically all the problems undertaken by the applied mathematical group here this one is of direct practical usefulness, in this case the reclamation of land for agriculture.

At present the whole centre is turning the major part of its interest to problems posed by the recent flood disaster. At all times each section -- applied mathematics, pure mathematics, statistics and computing -- must and are prepared to work on contracted problems. But today there is in addition a strong patriotic urge to cooperate.

Besides the work of the applied mathematicians and the computing section, the statistics section under Van Danzig is undertaking the determination of possible extremum values

from tables of observations. The specific problem at hand is that of finding the maximum possible water level outside existing dykes and possible new ones.

Belgium

At Liege, Florent Bureau outlined his current work on the problem of finding the fundamental solution of Oseen's equations for slightly compressible, slow, viscous flow. He discussed Douglis' proof of Hadamard's conjecture for hyperbolic equations. One of Bureau's assistants has found a serious uncorrectable mistake in Mattuisson's unpublished proof of this conjecture.

In Louvain I learned that a computing machine similar to the Mark 4 at Harvard is being built at Antwerp, jointly by the Belgian universities and the Belgium Bell Telephone Co. Nannebeck of Louvain is the mathematician in charge but he was away and I was unable to learn any further details.

Paris

The recent work of the group headed by P. Germain has been mostly in airfoil theory. By the method started by Tomatika and Tamada the equation of state is approximated. Corresponding explicit solutions for the equations of motion are found, some representing flow around profiles and some representing flow in channels. The theory is developed in the most general way. Two interesting results are the following:

1) A sequence of flows depending on a parameter ξ with a certain equation of state (a good approximation) which

[illegible] flows around various profiles. Each profile has a straight [illegible] of fixed angle [illegible]. Along the curved part of the profile the flow is sonic for all [illegible].

[illegible]
[illegible]
[illegible]
[illegible]

d) The inverse transformations of the stream functions and the potential functions satisfy an equation of the form $f(y)\psi_{xx} + \psi_{yy} = 0$. Using the same methods as in 1) you can find solutions. Even taking $f(y) = y$ is a pretty good approximation (better than using the same for the stream function itself) in a wide region. This can be used to find flows past warped profiles.

Germain also questioned non-existence of continuous transonic flow on the basis of some experimental results which have been done here and which are different from the usual tests. Suppose a symmetric profile that is also symmetric fore and aft is placed in a wind tunnel. If one measures the velocity near the profile for various Mach numbers at infinity M_∞ one observes the following: As the Mach number at infinity is increased a smooth symmetric supersonic region appears for a certain range of M_∞, say $M_1 < M_\infty < M_2$. However M_∞ varies from M_2 to $1.03M_2$. The flow becomes strikingly asymmetrical with what could be interpreted as a shock.

In Paris I also visited J. Leray and J. Hadamard.

With Leray I discussed some of our work with equations of mixed type. To Nadamard, I outlined the method of Douglis' proof of his conjecture in which he was very interested. I also discussed our work in mixed equations and Bers' work on pseudo-analytic functions.

London

There was some delay in my clearance and I missed seeing McNeil. However, I visited Thornhill at the Armament Research Establishment and discussed with him the Bethen problem of a spherical explosion. He outlined the difficulties in finding the singularity in the flow derivatives when the detonation surface reaches the edge of the explosive material. We also discussed the problem of shock diffraction and the singularities which occur in this case. He is completing the solution for the case of a moderate shock going around a 90° corner.

At the National Physics Laboratory, the computing machine was shown to me by Goodwin. It operates on a 9 A.M. to 10 P.M. schedule and has 70% efficiency. However lost time includes time wasted by giving the machine the wrong problem. I also saw the differential analyzer which for many of the problems done at N.P.L. is a more efficient tool.

At Cambridge I visited Batchelor. He is working now almost completely on electro-magnetic hydrodynamics (e.g., the motion of mercury in an electromagnetic field) and does little in the theory of turbulence. I also met G. I. Taylor.

Manchester

I spent two full days in Manchester talking with the applied mathematicians, the experimental aerodynamicist and seeing the computing machine. There is excellent cooperation between the experimental and the theoretical aerodynamicists. The theoretical emphasis is very much on getting explicit representations for solutions by simplifying problems in accordance with physical arguments. With Lighthill I discussed a wide variety of hydrodynamic problems especially his latest theory on the noise of turbulence. This theory has been largely corroborated by experiment but has a few serious discrepancies near sound speed. Owens showed me the laboratory - sub and supersonic wind tunnels and the turbulence apparatus.

The computing machine here operates continuously and very efficiently on a comparatively small staff. There is only limited interest in its application to partial differential equations because of the preference for closed solutions. Also applied mathematicians with problems for the machine must "see" their own problems through which means that they must know how to operate the machine and handle the programming.

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